FABRE-PEROT INTERFEROMETER

BACKGROUND OF THE INVENTION

[0001] A Fabre-Perot (FP) interferometer is a multiple-beam interferometer, usually consisting of two flat plates, one of which is light transmissive and the other of which is highly reflective. The two flat plates are set parallel to one another by spacers so that light waves may bounce back and forth between them multiple times. The interferometer makes use of multiple reflections between the two closely spaced flat plate surfaces. A resonant cavity or gap of the interferometer is a region bounded by the two flat plates, which in turn is adjusted or tuned to provide multiple reflections of light waves.

[0002] Typically, a large number of interfering light waves produces an interferometer with extremely high resolution. Because of the high resolution power, the FP interferometer is widely used as a spectrometer for the accurate measurement of the hyperfine structure of spectral lines. The FP interferometer is also used as a laser resonator, since it reinforces only light of specific frequencies traveling perpendicular to the mirror surfaces. It is advantageous to fine tune the resonant cavity of the interferometer to achieve high resolution.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Fig. 1 is a schematic diagram of a FP interferometer which is provided with first and second resonance cavity adjusting electromechanical transducers according to an embodiment of the invention.

[0004] Fig. 2 shows a circuit arrangement for controlling the first and second electromechanical transducers.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0005] Figures 1 and 2 are provided for illustration purposes only and are not intended to limit the present invention. Given the following disclosure one skilled in the art to which the present invention pertains or most closely pertains would recognize the various modifications and alternatives, all of which are considered to be a part of the present invention.

[0006] Fig. 1 represents an embodiment of an FP interferometer 100 which includes a top plate 102 and a bottom plate 104. The region bounded by the top plate 102 and the bottom plate 104 is a resonant cavity/gap 106. The top plate 102 is supported by flexures 108, which in turn are supported by posts 110. The height of the resonant cavity 106 is controlled by first and second electromechanical transducers. The first electromechanical transducer comprises the top plate 102, the bottom plate 104 and flexures 108 which resiliently support the top plate 102 over the bottom plate 104. This first electromechanical transducer, which functions as a linear acting motor, controls the height of the resonance cavity 106 by inducing a first relative displacement through a balance of electrostatic forces between the top plate 102 and the bottom plate 104, and mechanical spring forces of flexures 108. The top plate 102 and the bottom plate 104 act as first and second electrodes of a capacitor. By varying a voltage applied to the top plate 102, the distance between the top plate 102 and the bottom plate 104 can be varied and the height of the_resonant cavity 106 can be tuned/adjusted essentially to a desired value.

[0007] The second electromechanical transducer is associated with the bottom plate 104 and induces a second relative displacement between the top and bottom plates 102, 104, which is substantially independent of the first relative displacement, when energized. According to one embodiment, the second electromechanical transducer comprises a piezo-electric element 112.

[0008] The piezo-electric element 112 may comprise a single layer or plurality of layers. A bottom conductive plate 114 supports and provides an electrical connection for the piezo-electric element 112. The piezo-electric element 112 is disposed between the bottom plate 104 of the FP interferometer 100 and the bottom conductive plate 114. The hatched area 116 may include control circuitry and substrate.

[0009] In one embodiment, the top plate 102 is semi-transparent and the bottom plate 104 is reflective. An arrow 118 indicates light entering on the top plate 102. Arrows 120 and 122 indicate light exiting from the top plate 102 and the bottom plate 104, respectively. The color output of a DLD (diffractive light device) MEMS (microelectromechanical system) device is

controlled through the interference between light rays 120 and 122. The invention therefore finds application in such a device in that the use of the two electromechanical transducers permit fine control over the interference and thus the colors which are produced.

[0010] In one embodiment, the top plate 102 may be made from silicon dioxide. The bottom plate 104 and the bottom conductive plate 114 may comprise aluminum or an alloy of aluminum/tantalum. The piezo-electric element 112 may comprise zinc oxide or any other suitable piezo-electric material. The flexures 108 may comprise an alloy of aluminum/titanium and may act as electrodes for supplying a voltage to the top plate 102. However, the above materials are not limiting on the invention and any other suitable materials can also be used.

[0011] The FP interferometer 100 can be built using standard micro-electronic fabrication techniques such as photolithography, vapor deposition and etching. However, the above techniques are not limiting on the invention and any other suitable techniques can also be used. The disclosure of copending application entitled "Optical Interference Pixel Display with Charge Control", filed on April 30, 2003 and attorney docket no. 10016895-1, which relates to the fabrication of an interferometer of the type to which the embodiments of the invention are directed, is hereby incorporated by reference as an example of a fabrication technique.

[0012] In this embodiment, a method of fine tuning the resonant cavity 106 of the FP interferometer 100 is accomplished by changing the distance between the top plate 102 and the bottom plate 104 by using the piezo-electric element 112 between the bottom plate 104 and the bottom conductive plate 114. When voltage is applied across the bottom plate 104 and the bottom conductive plate 114, in one polarity, the piezo-electric element 112 will expand, decreasing the height of the resonant gap 106, which in turn decreases the distance between the top plate 102 and bottom plate 104. When voltage is applied in opposite polarity, the piezo-electric element 112 will contract, increasing the height of the resonant gap 106, which in turn increases the distance between the top plate 102 and bottom plate 104. These geometric modifications of the resonant gap 205, which are smaller than those induced by the linear acting motor (i.e. the first electomechanical transducer) comprised of the top

plate 102 and the bottom plate 104, can be achieved with a much higher slew rate and can be used to enable accurate tuning of the resonant cavity 106.

[0013] Referring to Fig. 2, one embodiment of a circuit arrangement for controlling the first and second electromechanical transducers is disclosed. The circuit arrangement comprises first and second voltage sources for controlling the first and second electromechanical transducers respectively. The first voltage source, 150 is connected across the top plate 102 and the bottom plate 104, whereas the second voltage source, 152 is connected across the bottom plate 104 and the bottom conductive plate 114. In this arrangement the bottom plate 104 is used as a common or ground. Though the bottom plate voltage V- need not be held at zero volts (as ground might imply), it is generally held steady while a top plate voltage V+ and a bottom conductive plate voltage Vmod are modulated. Thus, for the first stage of adjustment, the top plate 102 is moved for achieving what shall be referred to as "coarse" gap modulation. This is achieved by varying the top plate voltage V+. The second stage of adjustment uses the piezo-electric element 112 to provide what shall be referred to as "fine" gap modulation. This fine gap modulation is achieved by the bottom conductive plate voltage, Vmod, being adjusted and, in this instance, the bottom plate voltage, V-, being held constant.

[0014] The foregoing description of various embodiments of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the embodiments of invention disclosed, and modifications and variations are possible in light of the above teachings or may be acquired from practice of the invention. The embodiments were chosen and described in order to explain the principles of the invention and its practical application to enable one skilled in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. The scope of the invention is limited only by the appended claims.